AD-A067 973 ILLINOIS UNIV AT URBANA-CHAMPAIGN COMPUTER-BASED EDUC--ETC F/G 5/10
THE DANGER OF RELYING SOLELY ON DIAGNOSTIC ADAPTIVE TESTING WHE--ETC(U)
MAR 79 K TATSUOKA, M BIRENBAUM N00014-78-C-0159
UNCLASSIFIED CERL-E-5 NL

| OF |
AD
A067973

END
DATE
FILMED
6 -79
DDC

AD A067973

DDC FILE COPY

LEVEL II

(12)

Computer-based Education Research Laboratory

PLATO

University of Illinois Urbana Illinois

THE DANGER OF RELYING SOLELY ON DIAGNOSTIC ADAPTIVE TESTING WHEN PRIOR AND SUBSEQUENT INSTRUCTIONAL METHODS ARE DIFFERENT

KIKUMI TATSUOKA

MENUCHA BIRENBAUM

This research was sponsored by the Personnel and Training Research Program, Psychological Sciences Division, Office of Naval Research, under Contract No. N00014-78-C-0159. Contract Authority Identification Number NR 150-415.

PEG PLATO® Education Group

CERL REPORT E-5

MARCH 1979

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Research Report No. 2	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER 9 Research rept.
4. TITLE (and Subtitle) 6 The Danger of Relying Solely on Diagnostic Adaptive Testing When Prior and Subsequent Instructional Method are Different.		5. TYPE OF REPORT & PERIOD COVERED 1 October - 31 December 79
		6. PERFORMING ORG. REPORT NUMBER CERL Report E-5
7. AUTHOR(s) 10 Kikumi/Tatsuoka Menucha/Birenbaum		8. CONTRACT OR GRANT NUMBER(s) 15 N00014-78-C-0159
9. PERFORMING ORGANIZATION NAME AND ADDRESS Computer-based Education Research Laboratory University of Illinois Urbana, IL 61801		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 16 61133N; RR042-04 17 RR042-04-01; NR150-415
11. CONTROLLING OFFICE NAME AND ADDRESS Personnel and Training Research Programs Office of Naval Research (code 458) Arlington, VA 22217		12. REPORT DATE February 1979
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 11 Mar 79 12 43p.		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

14 CERL-E-5, RR-2

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

16

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

latent trait theory, logistic model, diagnostic adaptive test, computer managed routing system, information-processing strategies, integers operations, cluster analysis, unidimensionality, instructional methods, response patterns.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A computerized diagnostic adaptive test for a series of pre-algebra signed-number lesson (which are also on the computer system) was programmed along with a computer-managed routing system by which each examinee was sent to the instructional unit corresponding to the level of skill at which she/he stopped in the initial test. Upon completion of the course a computerized conventional posttest was given to the examinees. The posttest scores were far from being unidimensional, while (over)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

408 130

LB

cont fr p 1473A

the pretest and posttest data obtained from a previous study, in which the pretest was a computerized conventional test and students were forced to go through all instructional units regardless of their achievement in the pretest, indicated a strong tendency to be unidimensional. The response patterns of the posttest in the present study showed a high error rate for the skills prior to stopping levels for a subgroup of examinees.

A cluster analysis was performed on the response patterns and four different groups were found. A discriminant analysis indicated significant differences among the four groups in response patterns of the skills in signed number operations. After interviewing the teachers and several children, we came to the conclusion that it was the difference between prior and current instructional methods that confused students and caused a mess in the posttest data; ~~In other words,~~ i.e., there was a proactive inhibition effect.

The scoring procedure of the adaptive testing did not consider individual differences in information-processing skills which were affected by the instructional method used in previous teaching. Thus, the students who were taught to perform the beginning part of a set of hierarchically ordered skills by instructional method A would very likely get confused in a lesson in which a different instructional method B was adopted. Consequently, quite a few number of peculiar response patterns were seen in the performance on the posttest. This fact cautions us that one should be careful not to rely solely on test results determined by performance scores on a diagnostic pretest when a computer-managed instructional system is to route each examinee to their level of instruction. It was suggested that we must somehow unravel what information-processing strategy was used and consider this knowledge simultaneously.

1473B

THE DANGER OF RELYING SOLELY ON DIAGNOSTIC ADAPTIVE TESTING WHEN PRIOR AND SUBSEQUENT INSTRUCTIONAL METHODS ARE DIFFERENT

by

Kikumi Tatsuoka
and
Menucha Birenbaum

University of Illinois at Urbana-Champaign

This research was sponsored by the Personnel and Training Research Programs, Psychological Science Divesion, Office of Naval Research, under Contract No. N00014-78-c-0159. Contract Authority Identification Number, NR 150-415.

Research Report NO. 2

March 1979

ACKNOWLEDGEMENT

We wish to acknowledge the kind cooperation extended us by the mathematics teachers at Urbana Junior High School, particularly Ms. Mary Klein.

Julie Garrard gave us helpful editorial assistance, and Wayne Wilson provided careful artwork.

THE DANGER OF RELYING SOLELY ON DIAGNOSTIC ADAPTIVE TESTING WHEN PRIOR AND SUBSEQUENT INSTRUCTIONAL METHODS ARE DIFFERENT

Kikumi Tatsuoka

and

Menucha Birenbaum

ABSTRACT

A computerized diagnostic adaptive test for a series of pre-algebra signed-number lessons (which are also on the computer system) was programmed along with a computer-managed routing system by which each examinee was sent to the instructional unit corresponding to the level of skill at which she/he stopped in the initial test. Upon completion of the course a computerized conventional posttest was given to the examinees. The post-test scores were far from being unidimensional, while the pretest and post-test data obtained from a previous study, in which the pretest was a computerized conventional test and students were forced to go through all instructional units regardless of their achievement in the pretest, indicated a strong tendency to be unidimensional. The response patterns of the post-test in the present study showed a high error rate for the skills prior to stopping levels for one subgroup of examinees.

A cluster analysis was performed on the response patterns of the skills and four different groups were found. A discriminant analysis indicated significant differences among the four groups in

response patterns of the skills in signed number operations. After interviewing the teachers and several children, we came to the conclusion that it was the difference between prior and current instructional methods that confused students and caused a mess in the post-test data. In other words, there was a proactive inhibition effect.

The scoring procedure of the adaptive testing did not consider individual differences in information processing skills which were affected by the instructional method used in previous teaching. Thus, the students who were taught to perform the beginning part of a set of hierarchically ordered skills by instructional method A would very likely get confused in a lesson in which a different instructional method B was adopted. Consequently, quite a few peculiar response patterns were seen in the performance on the post-test. This fact cautions us that one should be careful not to rely solely on test results determined by performance scores on a diagnostic pretest when a computer-managed instructional system is to route each examinee to their initial level of instruction. It was suggested that we must somehow unravel what information processing strategy was used and consider this knowledge simultaneously.

INTRODUCTION

The computer-based education system (PLATO) at the University of Illinos has been widely utilized in teaching many different subject areas. The mathematics program at Urbana Junior High School (UJHS) is one of many that are currently on the PLATO system. Four terminals have been installed in the Mathematics Laboratory at UJHS so that they would be used by students from different classes as a part of their mathematics curriculum, and they had about an 80% rate of utilization during the time in operation. An increasing number of teachers have shown their interest in being involved with the PLATO mathematics program each semester. A great majority of the students, ranging from the best to the worst seemed to enjoy working with the PLATO lessons, especially with the game-lessons (Weaver, 1978).

About 70 lessons that teach a wide variety of subject areas from fundamental arithmetic such as decimal numbers to algebra and geometry have been presented by the system router, which allows a student or a teacher to choose a lesson from the index of available materials. This freedom of choice could be a troublesome task for a teacher because she has to determine which lesson would be the most appropriate instructional material for students who need remedial study of some topics. Moreover, without a larger number of terminals available no greater amount of time could be available for a student. Thus, adaptive diagnostic testing and computerized routing systems based on the results of the initial test become essential.

An adaptive test of signed numbers consisting of 12 groups of

items which represent 12 different skills was implemented along with a computer managed routing system. About 120 students took the initial test of adaptive testing although only 92 students completed the computerized conventional post-test given at the end of the instruction. It seemed that the children liked this "strange" format of testing. Some of them even volunteered to try the test for fun. However, the response patterns of the post-test revealed that the error-rate of the skills prior to the examinee's stopping level at the initial test was disturbingly high for some students. This fact contradicted our expectation that the scores on the post-test would satisfy a sufficient condition of the assumption of local independence--i.e., unidimensionality.

A close investigation of the behavior of the response patterns led us to consider a new aspect of the scoring procedure in adaptive testing which has been traditionally neglected.

A cluster analysis was performed on the 92 examinees' response patterns on the basis of Euclidian distances between pairs of response vectors, and four different groups were found. A discriminant analysis indicated significant differences among the four groups in terms of total scores on the 12 skills. After interviewing the teachers and several children, we came to the conclusion that it was the difference between prior and current instructional methods that confused the students and caused a mess in the post-test data. The two conflicting instructional methods created difficulty in following the instructions in the PLATO lesson for those students who operated addition of signed numbers by the method taught by one of the teachers. As will be

discussed later, the procedures of information processing associated with these two instructional methods of performing arithmetic upon signed numbers are greatly different. The traditional scoring procedure of the latent trait theory would not be capable of detecting these discrepancies based on the different information processes for arriving at the answers to a given item.

METHOD AND PROCEDURES

<u>Pretest</u>: A computerized conventional pre-test consisting of 64 items among which 4 or 6 items represented each of 14 different skills of integer (or signed number) operations was given to the pre-algebra classes at UJHS during the Spring semester of 1978. These items were displayed on the PLATO screen one at a time and were kept there until the student typed in his/her answer. No feedback, including a simple judging of either OK or NO to the answer, was given during the testing. After the pretest was taken, the classes began studying signed number operations, and at the same time the PLATO lessons started. The students eventually completed all instructional units in the lessons in which 14 skills were taught. Since the contents of these lessons adopted different teaching methods which became a crucial theme of this study, a brief description of the methods will be given below.

<u>The Number Line Method</u>: In the lesson "signum" written by Tamar Weaver, the concept of negative integers was taught by means of moving a pointer to the left on the number line starting from the origin zero. Addition

of numbers was associated with moving a pointer to the right by the number of units equivalent to the addend, while subtraction was taught by moving the pointer to the left by the number of units corresponding to the subtrahend. This geometric method did not seem to be successful in teaching problems involving double signs. (Problems such as: (-1)-(-7) as Weaver [1978] pointed out in his paper.) Students seemed to have trouble in understanding how double signs work in a geometric way, with a negative sign in front of a negative number causing a pointer to be reflected through the origin on the number line. Students who were successful in problems with double signs showed a different way of approaching the problem.

Madison Mathematics Project (Davis, 1964): A new approach was presented by this project. Positive and negative integers were associated with checks and bills, respectively. Addition was represented by a mailman's bringing something (a check or a bill), while subtraction corresponded to the mailman's taking something from the house. Also this method didn't use parentheses such as 1+(-3) which appears in the Number Line method. Instead, signs were written at the upper left of a number, like $1+{}^{-}3$ and it was clearly distinguished from an operational sign of addition + . With this approach students were very successful at working problems involving double signs but many failed to see the problem as a signed number subtraction problem in general. Weaver stated that when the students using this method were asked to work the problem as a subtraction problem directly, they failed.

The teachers' method: A teacher who is the head of the mathematics department at UJHS followed the Madison project method but he has changed the presentation of problems substantially. He has used a sequential method: that is, starting with a problem that children already know, say $5 - 3 = 2$ he subsequently presented $5 - 4 = 1$, $5 - 5 = 0$. Next, he asked what $5 - 6$ will be, assuming children know that -1 lies immediately to the left of zero on the number line.

In contrast to the above, another teacher taught signed number operations mainly by showing examples of various skills and emphasized memorizing the rules of operations.

Treatment and Post-test: The class of Spring 1978 studied two types of lessons: one in which one method was used to teach signed-number operations, and the other, the other method. A computerized conventional 64-item test was administered upon completion of the PLATO course. This post-test will be referred to as post-test1 hereafter in the paper.

Diagnostic Adaptive Testing: An unconventional test was constructed on the bases of item characteristic information obtained from the pretest item scores.

First, the computer program that estimates item discriminating powers (a's) and item difficulties (b's) of the two parameter logistic model, by the maximum likelihood method, was written on the PLATO system by Robert Baillie. The iterations in the program (called "getab") start

with a special set of initial parameter values (given by Lord & Novick, 1968, Chapter 16) and continues until the estimated parameter values converge to the constant. This program successfully provided the convergent estimated values of a's and b's for most of the 64 items in the pre-test and θ values for 83 students. Since the pretest was a computerized free-response test, it was considered that guessing would be a negligible factor. Moreover, the coefficient α of the pretest was as high as .974.

The adaptive test of signed numbers consisted of 12 groups of items representing 12 different skills. The pretest contained 14 different skills but two skills were dropped in the diagnostic adaptive test, due to the shortage of PLATO terminals available at UJHS. Besides that, the lessons that dealt with those skills, multiplication and division of signed numbers, would have added another 50-60 minutes to the program.

In the pretest, one item from each skill of the total of 14 skills was given first, then the second item from all 14 skills was given in the same order of skills as in the first 14 items. Thus, each skill was examined by either four or six parallel items in the test. A close examination of the items testing the same skill revealed that the item parameters of these parallel items did not show much noticeable difference. Therefore, the averages of a's and b's in a skill were taken to designate the characteristics of each of the 14 skills. Table 1 presents examples of items from each of the 12 skills that were used in the adaptive test and their average indices of item difficulties, means and standard deviations.

Table 1

Means and Item Difficulties of the Twelve Skills in the Pretest of Signed Numbers in Spring 1978

	Skill Type	Mean	and SD	Difficulty
1	2>-5	2.66	1.69	-1.67
2	6 right of -2	1.87	1.76	-1.51
3	(-2)+(-5)	3.15	1.28	-1.37
4	-8+7	3.00	1.51	-1.06
5	2+(-6)	3.21	1.19	-.86
6	(-3)-(-2)	1.51	1.74	-.76
7	5-6	1.71	1.84	-.49
8	-(-7)	1.79	1.73	-.01
9	(-4)-(-6)	2.61	1.55	.10
10	-1-5	3.65	2.32	.15
11	2-(-7)	3.50	2.25	.22
12	(-6)-(+5)	5.22	1.31	.36

Procedure of Adaptive Testing: The newly developed adaptive test and routing system were tried during the Fall semester of 1979. Administering the test to the classes of 8th graders began a week after the regular classroom instruction started teaching the signed-number operations. All students were expected to know the number line and what negative integers are. Moreover, most students had learned more or less how to add any two integers. Thus, the starting item of the diagnostic adaptive test was selected from Skill No. 6, (-3)-(-2) type. According to the result of his/her answer, a skill either one step harder or one step easier was next tested. This procedure was repeated until the "stopping criterion" was satisfied. Each examinee was routed to the instructional unit corresponding to the level of skill at which he/she stopped in the initial test. The instructional units of the PLATO lesson that teach the same 12 skills by the Number Line method also were rearranged into the same order as the skills in the adaptive test, so that if an examinee stopped at the 7th skill level he was sent to the

7th instructional unit. After he went through the 7th to 12th instructional units, the student completed the lesson and a 52-item conventional computerized post-test (post-test2) was administered to him. Performance score and response latency of each item as well as the performance records and mastery time of each instructional unit were collected for all students.

Stopping Criterion of Testing: The θ values estimated by the maximum likelihood method were not used in routing students into the lesson because this estimation method did not converge for all response patterns. Nonconverging cases will halt the routing system thus forcing us to forgo using the θ values to decide on the stopping levels of the skills. If the estimated θ values are always obtainable, then it is commendable to choose a subsequent item from the remaining items so as to maximize the amount of information at a subject's true ability level θ (Samejima, 1978). Tatsuoka (1979) derived the least-squares estimation method of the θ values by a Hilbert space approach. The beta weights for earlier terms in the multiple regression equation remain unaltered when subsequent terms are added in a stepwise manner. With this method, the θ values are always obtainable even for unusual response patterns or extreme values of θs as well. This method will be applied to the future use of adaptive testing on the PLATO system. Our current stopping criterion is similar to the one of stradaptive testing which was discussed by Weiss (1973), Dewitt and Weiss (1974), and Waters (1978).

ANALYSES AND CLASSIFICATION OF RESPONSE PATTERNS

Dimensionality of Post-test2: We assumed first that the post-test2 data would not have obviously more than two dimensions, inferring from the fact that both the pretest and post-test1 data had a strong tendency toward unidimensionality. Therefore, we arranged the skills into a linearly related hierarchical structure and applied the latent trait model to determine item characteristic parameters. Figure 1 presents a scree-test of the eigenvalues obtained by a principal component analysis for the pretest, post-test1 and post-test2 data. As can be seen in the figure, the pre and post-test1 data share an almost identical pattern, which consists of one substantial eigenvalue that accounts for about half of the variance (Table 2 presents the amount of variance accounted for by each eigenvalue). The second eigenvalue, the magnitude of which exceeds a unity, accounts for only 13% of the variance. The pattern of the post-test2 data is different. Four eigenvalues in this case exceed

Table 2

The Percent of Variance Accounted for by the Corresponding Eigenvalues in a Principal Component Analysis of Pre and Post Data of the Classes of Spring 1978 and the Posttest of Adaptive Test Study in Fall of 1978

	Spring-1978 Percent of Variances		Fall-1978 Percent of Variances
	Pretest	Posttest	Posttest
1	53.1	49.8	27.6
2	13.6	13.0	14.9
3	6.3	7.7	12.9
4	5.7	6.1	9.2
5	4.2	5.2	7.0
6	3.9	3.9	6.2
7	3.0	3.3	5.7
8	2.8	2.5	5.3
9	2.3	2.3	3.8
10	1.3	2.0	3.3
11	1.3	1.5	2.6
12	1.1	1.4	1.6
13	.7	.7	
14	.6	.6	

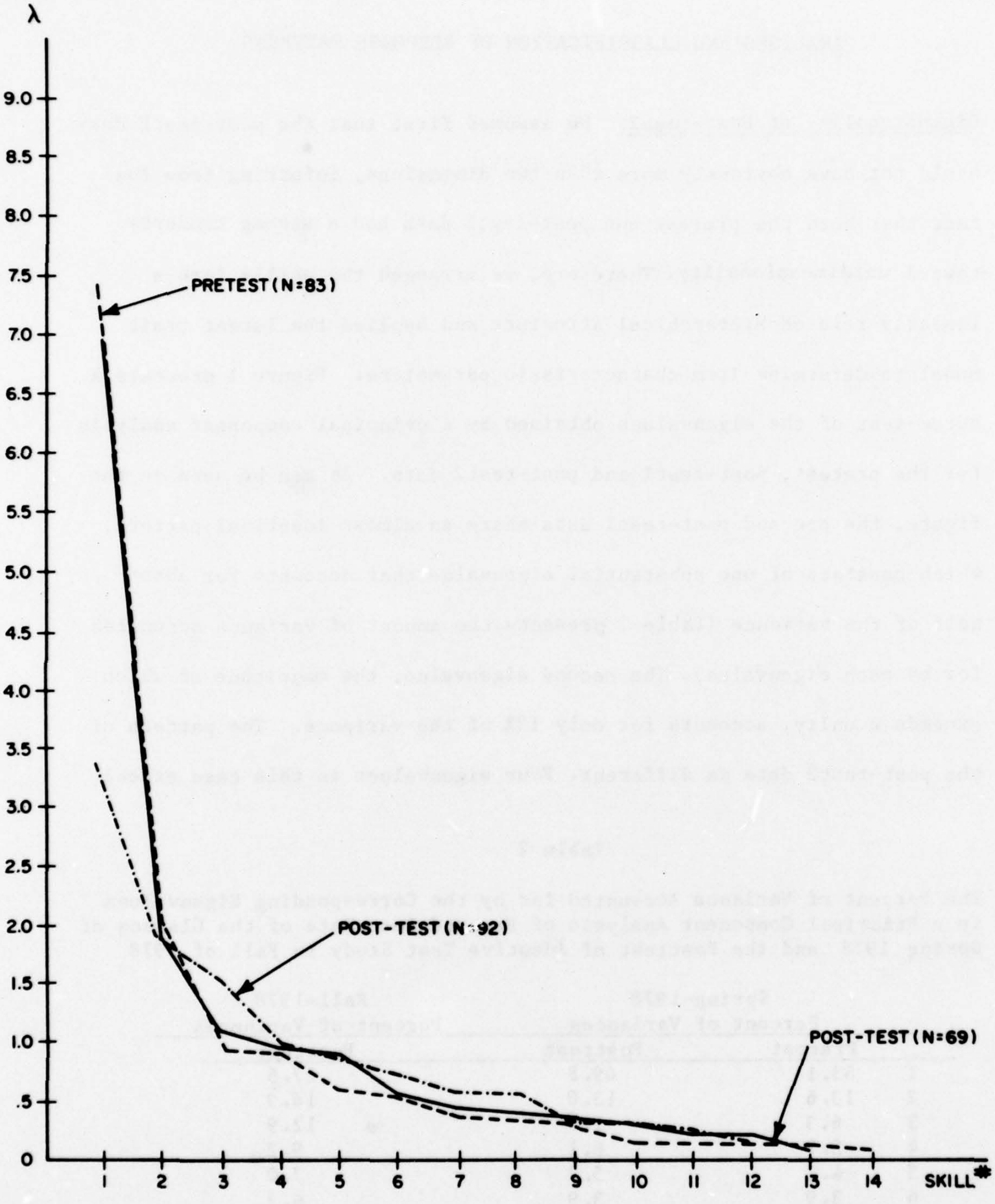

Figure 1 Screetest: Eigenvalues extracted in a principal component analysis.

unity but the differences in magnitude among these four eigenvalues are relatively smaller. The amount of variance accounted for by all four eigenvalues is 65%. We can therefore conclude that while the post-test1 data shows a certain tendency toward unidimensionality, the structure of the post-test2 data departs from unidimensionality to a much greater extent.

The increasing dimensionality of the post-test data as compared with those of the previous group may indicate that other factors were interacting with the basic ability of manipulation with signed numbers. As was mentioned before, in the adaptive testing program students were taught the basic levels of signed numbers by means of the ordinary classroom teaching methods which in many cases happened to differ from the method presented by the computerized instruction. These differences referred not only to the medium of presentation, the style and the notation used, but more importantly they differed also with respect to the conceptualization of the material. We can therefore assume that for some students in this group, the adaptive instruction--to which they were routed according to their performance in the pretest--was a different experience from what they were previously taught. This situation in which the teaching method wasn't consistent with their former background not only caused their lack of understanding for the new material, but may also have confused them as to materials they had previously mastered. This, of course is one possible explanation.

An alternative explanation may question the reliability of the routing procedure, claiming an invalid hierarchy or violation of the

local independence assumption underlied the logistic model, upon which the routing process was based. Although the pretest data showed a tendency toward unidimensionality which is a prerequisite for hierarchical structure as well as for the latent trait model, there were still other sources of systematic variation in the data. This may have caused less reliable estimates regarding the starting point in the instructional unit.

Although the first explanation seems more plausible, it is impossible at this stage to exclude the second one entirely. In order to do so, an experimental design should have been carried out including a third group which should have taken the adaptive test and the entire instructional unit, and a fourth group which should have been taught the previous material in a method similar to the one offered by the computerized instructional unit. A comparison of the groups' results in the post-test may have lent support to one of the above mentioned tentative explanations.

Identifying a Typology of Response Patterns on Post-test2: The multidimensionality that emerged in the post-test2 data of the adaptive testing group indicated the existence of different patterns of responses to the 12 skills measured by that test. In order to classify the different patterns into a more meaningful typology, a cluster analysis was applied (i.e., students were clustered according to the similarity of their responses on the post-test items). The method of clustering the cases was based on the hierarchical model (Hubert & Baker, 1976). The computer program used was the BMDP2M (1977). This

procedure performs an hierarchical cluster analysis based on the average linkage algorithm. Initially the program considers each object to be in a cluster of its own. At each step the two clusters with the shortest distance (which is defined by Euclidian distance between two response vectors) between them are combined and treated as one cluster. This process of combining clusters continues until all the objects are combined into one cluster. The final result obtained on letting the computer program run its full course is obviously a trivial one, for it constitutes no partitioning of the original total group. A partitioning at some intermediate stage must be chosen on the basis of some criterion involving "a trade-off between the loss of information as the partition level increases (i.e., as larger groups are formed) and the greater ease with which substantive interpretations made by the research when the number of groups in the partition is small" (Hubert & Baker, 1976). In the present case, a careful examination of the tree diagram printed by the computer program led to a partition with four subgroups of students, defined by their response pattern to the 52 post-test items. In order to validate this classification and to identify the differences among the four response-pattern types in terms of the 12 skills, a discriminant analysis was carried out. Tables 3 and 4 present the results of this analysis. As can be seen in the tables, two functions yield highly significant discrimination among the groups. The discriminant analysis enables us to identify the nature of these response types.

Table 3

Centroid & Coefficient of Determination for the 12 Skills on the 3 Discriminant Functions (N=91)

Group	N	I	II	III
1	34	-.571	.280	-.280
2	27	.951	-.132	-.160
3	20	-.005	.427	.590
4	10	-.614	-1.448	.203
λ		.775	.446	.135
R_c		.661	.555	.345
$(1-\Lambda)100$		66%	39%	12%
p<		.0001	.001	.230

Table 4

Standardized Coefficient for the 12 Skills on 3 Discrininant Functions

	Discriminant Functions		
Skill	I	II	III
1	.397	.186	-.627
2	.479	-.038	.601
3	.175	.534	-.196
5	.185	-.209	.350
6	-.109	.773	-.055
7	.289	.180	-.243
8	-.244	.313	-.260
9	-.214	-.468	.670
10	-.150	.401	.725
11	-.517	.082	-.622

One dimension along which the greatest differences occur involves skills 1,2,7 vs. 8,9,11. This dimension best discriminates Group 2 from the rest. As can be seen in Figure 2, the profile of this group when considered for each skill separately reflects an extreme profile. While this group compared with the other three showed the best performance on the lower level skills, its performance on the higher

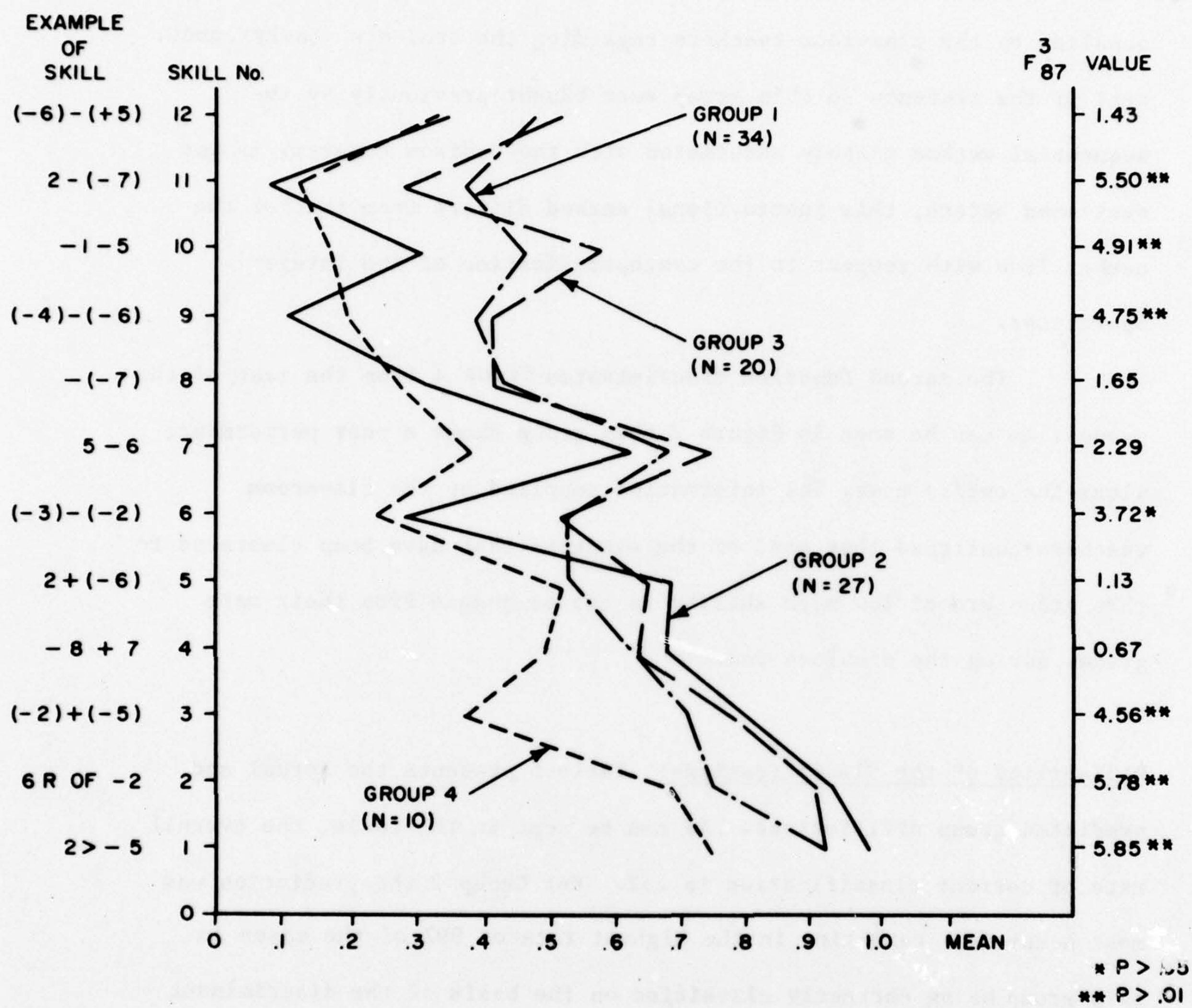

Figure 2 Profiles of the mean performance on each skill in the post-test for four groups formed via cluster analysis.

level skills is almost the poorest. According to the information supplied by the classroom teachers regarding the students' backgrounds, most of the students in this group were taught previously by the sequential method closely associated with the Madison Program. As was mentioned before, this instructional method differs from that of the number line with respect to the conceptualization of the integer operations.

The second function discriminates Group 4 from the rest of the groups. As can be seen in Figure 2 this group shows a poor performance along the entire test. The information supplied by the classroom teachers confirmed that most of the students that have been clustered to this group are of low math ability as can be judged from their math grades during the previous year.

<u>Reliability of the Classifications</u>: Table 5 presents the actual and predicted group affiliations. As can be seen in the table, the overall rate of correct classification is 65%. For Group 2 the prediction was most accurate, resulting in the highest rate of 89% of the cases in this group being correctly classified on the basis of the discriminant function scores.

Based on this experience it seems that a cluster analysis of the response patterns followed by a discriminant analysis has the potential of providing valuable information that may help to identify problems in the teaching-learning process.

Table 5

Actual and Predicted Group Afiliation of the Four Response Pattern Types (in percent)

Actual Groups	N	Predicted Groups 1	2	3	4	%total
1	34	55.9	0.0	26.5	17.6	37.4
2	27	3.7	88.9	7.4	0.0	29.6
3	20	20.0	30.0	45.0	5.0	22.0
4	10	0.0	30.0	0.0	70.0	11.0
Predicted %		26.4	36.3	22.0	15.3	100.0

64.8% of the cases were correctly classified.

DISCUSSION AND CONCLUSIONS

The results of this study raised two important, albeit closely related, issues concerning adaptive testing and computer managed routing by which each examinee was sent to his/her most appropriate instructional level, i.e., his/her adaptive instructional unit, diagnosed by the initial adaptive test.

The first issue is how one could improve the scoring procedure of adaptive testing by taking into account individual differences in information processing skills that were usually affected by instructional method used in previous teaching. Many psychological studies pertinent to an information processing view of mental abilities have been done recently by cognitive psychologists. (See for example: Anderson et al., 1978; Carroll, 1978; Frederiksen, C., 1969; Frederiksen, J., 1978; Groen & Perkum, 1972; Heller & Greeno, 1978; Hunt et al., 1973; Rose, 1977; Sternberg, 1978a, 1978b; Sternberg & Rifkin, 1978.) The results of these

studies have indicated the exsistence of a series of cognitive processes which differed among individuals. However, the stability and the generality of these traits have not been definitely confirmed yet.

A cluster analysis performed on the similarity of response patterns on the test separated a group whose members seemed to use alternative processes in doing some test items. They did very well on the items of the skills prior to the stopping level on the diagnostic adaptive test, but did not learn much in their adaptive instructional units. When the list of names in this group was presented to the teachers, it caused surprise because the members of this group were considered fairly good students and the teachers expected them to be able to perform much better on the test. The two conflicting instructional methods, a prior instructional method taught by a teacher and a subsequent one presented by the adaptive instructional unit caused confusion in learning non-mastered skills for those students. It therefore seems that in order to improve the adaptive procedure, the students' strategy of information processing, due to their previous learning experience should be taken into consideration as well.

The second issue was the dimensionality of the performance scores on the test administered at the end of adaptive instructions. Since the items in post-test1 and post-test2 are identical, we expected that the dimensionality of post-test2 would be almost the same as that of post-test1. Post-test1 data obtained from a previous study showed a strong tendency toward unidimensionality, but post-test2 data did not show it. In order to speculate about the reason why the dimensionalities of the two post-tests are different, we must examine

the differences between the amounts of treatment given in the previous study (Spring of 1978), and the current study (Fall of 1978). In the previous study, the students studied both PLATO lessons: One in which the Madison Project approach was used, and the other, the Number Line approach to teach signed-number operations. Moreover, the students represented in post-test1 data studied a whole segment of the lesson by the Number Line Method, while those in post-test2 data studied only a part of this lesson--starting from the unit to which they were routed. Naturally, the means of all skills in post-test1 were higher than those in post-test2, and 7 out of 12 skills were significantly high. This discrepancy <u>may</u> imply that if a given topic is considerably well mastered by a majority of students, the post-test will show a strong tendency toward unidimensionality no matter what kinds of information-processing strategies were used by individuals. As was seen in this study, on the other hand, when learning is still far from the stage of mastery, and different instructional methods create confusion among students, the dimensions of a test given at this point will be chaotic.

Solutions to the first issue have not been fully explored. However, it seems that multivariate assessment of performance scores and response latency, or more precisely, the notion of conditional response rate (Tatsuoka & Tatsuoka, 1978), might be an appropriate solution. Exploration of time data indicated that the curves of conditional response rate function (or hazard rate function [Mann et al., 1974]) of a given item in Group 1 and 2 found in the cluster analysis results were obviously different from one another. That is, the curve obtained from Group 2 strongly suggested a Poisson process for the problems of

additions, while that from Group 1 had a monotonically increasing conditional response rate function for the same items. This matter will be further discussed in Technical Report No. 3.

A second possible solution to the first issue is to investigate closely the behavior of response patterns on the test. As mentioned earlier, each instructional method had a unique strength and weakness in teaching a given skill. It was easier to teach problems of double signed numbers with the Madison Project method than with the Number Line method. Application of S-P curves (Sato, 1977; K. Tatsuoka, 1978; M. Tatsuoka, 1978) or Cliff's consistency index (1977) seem to have the potential of providing a solution to the above mentioned issue of improving the scoring procedure for adaptive testing.

REFERENCES

Anderson, J.R., Kline, P.J., Beasley, C.M., Jr. A theory of the acquisition of cognitive skills. New Haven: Yale University, Department of Psychology, 1978.

Carroll, J.B. How shall we study individual differences in cognitive ability? -- Methodological and theoretical perspectives (Technical Report 1). Chapel Hill: University of North Carolina, Psychometric Laboratory, 1978.

Cliff, N.A. A theory of consistency of ordering generalizable to tailored testing. Psychometrika, 1977, 375-399.

Davis, R.B. The Madison Project, discovery in mathematics; a text for teachers. Reading: Addison-Wesley, 1964.

DeWitt, L.J., & Weiss, D.J. A computer software system for adaptive ability measurement (Research Report 74-1). Minneapolis: University of Minnesota, Department of Psychology, Psychometric Laboratory, 1974. (AD 773961)

Frederiksen, C.H. Abilities, transfer, and information retrieval in verbal learning. Multivariate Behavioral Research Monographs, 1969, No. 69-2.

Frederiksen, J.R. Assessment of perceptual decoding and lexical skills and their relation to reading proficiancy. In A.M. Lesgold, J.W. Pellegrino, S. Fokkema, and R. Glaser (Eds.), Cognitive psychology and instruction. New York: Plenum Press, 1978.

Groen, G.J., & Perkum, J.M. A chronometric analysis of simple addition. Psychological Review, 1972, 79, 329-343.

Heller, J.I., & Greeno, J.G. Information processing analyses of mathematical problem solving. Unpublished manuscript, University of Pittsburgh, 1978.

Hubert, L., & Baker, F.B. Data analysis by single-link and complete-link hierechical clustering. Journal of Educational Statistics, 1976, 1(2), 87-111.

Hunt, E., Frost, N., & Lunneborg, C. Individual differences in cognition. In G. Bower (Ed.), The psychology of learning and motivation: Advances in research and theory (Vol.7). New York: Academic Press, 1973.

Lord, F.M., & Novick, M.R. Statistical theories of mental test scores. Reading: Adison-Wesley, 1968.

Mann, N.R., Schafer, R.E., & Singpurwalla, N.D. Methods for Statistical analysis of reliability and life data. New York: John Wiley & Sons, 1974.

Rose, A.M. An information processing approach to performance assessment (Final Report). Washington, D.C.: American Institutes for Research, November 1978.

Samejima, F. Effects of individual optimization in setting the boundaries of dichotomous items on accuracy of estimation. Applied Psychological Measurement, 1978, 1, 77-94.

Sato, T. Diagnostic and formative evaluation of data processing system. In T. Sato (Ed.), Computer managed instruction system. Tokyo: Electronics Communication Inc., 1977.

Sternberg, R. The nature of mental abilities (Technical Report No. 9). New Haven: Yale University, Department of Psychology, 1978a.

Sternberg, R. Contrasting conceptions of intelligence and their educational implications (Technical Report No. 14). New Haven: Yale University, Department of Psychology, 1978b.

Sternberg, R., & Rifkin, B. The development of analogical reasoning processes. Journal of Experimental Child Psychology, in press, 1978.

Tatsuoka, K.K. Psychometrical and statistical properties of response time. Paper presented at the joint meeting of the Psychometric Society and the Society for Mathematical Psychology, Hamilton, Ontario, June 1978.

Tatsuoka, K.K. The least-squares estimation of latent variables by a Hilbert space approach (Research Report E-3). Urbana, Ill.: University of Illinois, Computer-based Education Research Laboratory, 1979.

Tatsuoka, K.K., & Tatsuoka, M.M. Time-score analysis in criterion-referenced tests (CERL Report E-1). Final Report for NIE project No. NIE-G-76-0087. Urbana, Ill.: University of Illinois, Computer-based Education Research Laboratory, February 1978.

Tatsuoka, M.M. Recent psychometric developments in Japan: Engineers grapple with educational measurement problems. Paper presented at ONR Contractor's meeting, Columbia, Missouri, September 1978.

Waters, B.K. An empirical investigation of the stratified adaptive computerized testing model. Applied Psychological Measurement, 1978, 1, 141-154.

Weaver, C. Classroom observation report: Urbana Junior High School PLATO project. Unpublished manuscript, University of Illinois, Computer-based Education Research Laboratory, 1978.

Weiss, D.J. The stratified adaptive computerized ability test (Research Report 73-3). Minneapolis: University of Minnesota, Department of Psychology, Psychometric Laboratory, 1973. (AD 768376)

Distribution List

Navy

Dr. Ed Aiken
Navy Personnel R and D Center
San Diego, CA 92152

Dr. Jack R. Borsting
Provost and Academic Dean
U.S. Naval Postgraduate School
Monterey, CA 93940

Dr. Robert Breaux
Code N-71
NAVTRAEQUIPCEN
Orlando, Fl 32813

Mr. Maurice Callahan
Pers 23a
Bureau of Naval Personnel
Washington, DC 20370

Dr. Richard Elster
Department of Administrative Sciences
Naval Postgraduate School
Monterey, CA 93940

Dr. Pat Frederico
Navy Personnel R and D Center
San Diego, CA 92152

Dr. Paul Foley
Navy Personnel R and D Center
San Diego, CA 92152

Dr. John Ford
Navy Personnel R and D Center
San Diego, CA 92152

Dr. Richard Gibson
Bureau of Medicine and Surgery
Code 513
Navy Department
Washington, DC 20372

Capt. D.M. Gragg, MC, USN
Head, Section on Medical Education
Uniformed Services Univ. of the Health Sciences
6917 Arlington Road
Bethesda, MD 20014

Lt. Steven D. Harris, MSC, USN
Code 6041
Human Factors Engineering Division
Crew Systems Department
Naval Air Development Center
Warminster, Pennsylvania 18974

CDR Wade Helm
PAC Missile Test Center
Point Mugu, CA 93041

LCDR Charles W. Hutchins
Naval Air Systems Command
444 Jefferson Plaza # 1
1411 Jefferson Davis Highway
Arlington, VA 20360

Dr. Norman Kerr
Chief of Naval Technical Training
Naval Air Station Memphis (75)
Millington, TN 38054

Dr. Leonard Kroeker
Navy Personnal R and D Center
San Diego, CA 92152

Chairman, Leadership and Law Dept.
Div. of Professional Development
U.S. Naval Academy
Annapolis, MD 21402

Dr. William L. Maloy
Principal Civilian Advisor for Education and Training
Naval Training Command, Code 00A
Pensacola, FL 32508

CAPT Richard L. Martin
USS Francis Marion (LPA-Z49)
FPO New York, NY 09501

Dr. James McBride
Code 301
Navy Personnel R and D Center
San Diego, CA 92152

Dr. James McGrath
Navy Personnel R and D Center
Code 306
San Diego, CA 92152

Dr. William Montague
LRDC
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15213

Commanding Officer
Naval Health Research
Center
ATTN: Library
San Diego, CA 92152

Naval Medical R and D Command
Code 44
National Naval Medical Center
Bethesda, MD 20014

Library
Navy Personnel R and D Center
San Diego, CA 92152

Commanding Officer
Naval Research Laboratory
Code 2627
Washington, DC 20390

Office of Civilian Personnel
(Code 26)
Dept. of the Navy
Washington, DC 20390

John Olsen
Chief of Naval Education and
Training Support
Pensacola, FL 32509

Psychologist
ONR Branch Office
495 Summer Street
Boston, MA 02210

Psychologist
ONR Branch Office
536 S. Clark Street
Chicago, IL 60605

Code 436
Office of Naval Research
Arlington, VA 22217

Office of Naval Research
Code 437
800 N. Quincy Street
Arlington, VA 22217

Personnel and Training Research
Programs (Code 458)
Office of Naval Research
Arlington, VA 22217

Psychologist
Office of Naval Research Branch
223 Old Marylebone Road
London, NW, 15th England

Psychologist
ONR Branch Office
1030 East Green Street
Pasadena, CA 91101

Scientific Director
Office of Naval Research
Scientific Liaison Group/Tokyo
American Embassy
APO San Francisco, CA 96503

Office of the Chief of Naval Operations
Research, Development, and Studies Branch
(OP-102)
Washington, DC 20350

Scientific Advisor to the Chief of
Naval Personnel (Pers-Or)
Naval Bureau of Personnel
Room 4410, Arlington Annex
Washington, DC 20370

LT Frank C. Petho, MSC, USNR (Ph.d)
Code L51
Naval Aerospace Medical Research
Laboratory
Pensacola, FL 32508

Dr. Richard A. Pollak
Academic Computing Center
U.S. Naval Academy
Annapolis, MD 21402

Roger W. Remington, Ph.D.
Code L52
NAMRL
Pensacola, FL 32508

Dr. Bernard Rimland
Navy Personnel R&D Center
San Diego, CA 92152

Mr. Arnold Rubenstein
Naval Personnel Support Technology
Naval Material Command (08T244)
Room 1044, Crystal Plaza #5
2221 Jefferson Davis Highway
Arlington, VA 20360

A. A. Sjoholm
Tech. Support, Code 201
Navy Personnel R and D Center
San Diego, CA 92152

Mr. Robert Smith
Office of Chief of Naval Operations
OP-987E
Washington, DC 20350

Dr. Alfred F. Smode
Training Analysis and Evaluation
Group (TAEG)
Dept. of the Navy
Orlando, FL 32813

Dr. Richard Sorensen
Navy Personnel R and D Center
San Diego, CA 92152

CDR Charles J. Theisen, Jr., MSC, USN
Head Human Factors Engineering Div.
Naval Air Development Center
Warminster, PA 18974

W. Gary Thomson
Naval Oceans Systems Center
Code 7132
San Diego, CA 92152

Dr. Ronald Weitzman
Department of Adminstrative Sciences
U.S. Naval Postgraduate School
Monterey, CA 93940

Dr. Martin F. Wiskoff
Navy Personnel R and D Center
San Diego, CA 92152

Army

Technical Director
U. S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

HQ USAREUE and 7th Army
ODCSOPS
USAAREUE Director of GED
APO New York 09403

Dr. Ralph Canter
U. S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Ralph Dusek
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Myron Fischl
U.S. Army Research Institute for the Social and Behavioral Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Ed Johnson
U. S. Army Research Institute
5001 Eisenhower Blvd.
Alexandria, VA 22333

Dr. Michael Kaplan
U. S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Milton S. Katz
Individual Training and Skill
Evaluation Technical Area
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Harold F. O'Neil, Jr.
Attn: PERI-OK
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Robert Ross
U.S. Army Research Institute for the
Social and Behavioral Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

Director, Training Development
U.S. Army Administration Center
ATTN: Dr. Sherrill
Ft. Benjamin Harrison, IN 46218

Dr. Frederick Steinheiser
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Joseph Ward
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Air Force

Air Force Human Resources Lab
AFHRL/PED
Brooks AFB, TX 78235

Air University Library
AUL/LSE 76/443
Maxwell AFB, AL 36112

Dr. Philip De Leo
AFHRL/TT
Lowry AFB, CO 80230

Dr. G. A. Eckstrand
AFHRL/AS
Wright-Patterson AFB, OH 45433

CDR. Mercer
CNET Liaison Officer
ARGRL/Flying Training Div.
Williams AFB, AZ 85222

Dr. Ross L. Morgan (AFHRL/ASR)
Wright-Patterson AFB
Ohio 45433

Dr. Roger Pennell
AFHRL/TT
Lowry AFB, Co 80230

Personnel Analysis Division
HQ USAF/DPXXA
Washington, DC 20330

Research Branch
AFMPC/DPMYP
Randolph AFB, TX 78148

Dr. Malcolm Ree
AFHRL/PED
Brooks AFB, TX 78235

Dr. Marty Rockway (AFHRL/TT)
Lowry AFB
Colorado 80230

Jack A. Thorpe, Capt, USAF
Program Manager
Life Sciences Directorate
AFOSR
Bolling AFB, DC 20332

Brian K. Waters, LCOL, USAF
Air University
Maxwell AFB
Montgomery, AL 36112

<u>Marines</u>

MCDEC
Quantico Marine Corps Base
Quantico, VA 22134

Dr. A. L. Slafkosky
Scienfitic Advisor (Code RD-1)
HQ, U.S. Marine Corps
Washington, D.C. 20380

Coast Guard

Mr. Joseph J. Cowan, Chief
Psychological Research (G-P-1/62)
U.S. Coast Guard HQ
Washington, D.C. 20590

Dr. Thomas Warm
U.S. Coast Guard Institute
P.O. Substation 18
Oklahoma City, OK 73169

Other DoD

Defense Documentation Center
Cameron Station, Bldg. 5
Alexandria, VA 22314
Attn: TC

Dr. Dexter Fletcher
Advanced Research Projects Agency
1400 Wilson Blvd.
Arlington, VA 22209

Dr. William Graham
Testing Directorate
MEPCOM
Ft. Sheridan, IL 60037

Military Assistant for Training and
Personnel Technology
Office of the Under Secretary of
Defense for Research and Engineering
Room 3D129, The Pentagon
Washington, DC 20301

Major Wayne Sellman, USAF
Office of the Assistant Secretary
of Defence (MRA and L)
3B930 The Pentagon
Washington, DC 20301

Civil Government

Dr. Susan Chipman
Basic Skills Program
National Institute of Education
1200 19th Street NW
Washington, DC 20208

Dr. William Gorham, Director
Personnel R and D Center
U.S. Civil Service Commission
1900 E Street NW
Washington, DC 20415

Dr. Joseph I. Lipson
Division of Science Education
Room W-638
National Science Foundation
Washington, DC 20550

Dr. John Mays
National Institute of Education
1200 19th Street NW
Washington, DC 20208

Dr. Arthur Melmed
National Institute of Education
1200 9th Street NW
Washington, DC 20208

Dr. Andrew B. Molnar
Science Education Dev.
and Research
National Science Foundation
Washington, DC 20550

Dr. Lalitha P. Sanathanan
Environmental Impact Studies Division
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, IL 60439

Dr. Jeffery Schiller
National Institute of Education
1200 19th St. NW
Washington, DC 20208

Dr. Thomas G. Sticht
Basic Skills Program
National Institute of Education
1200 19th Street NW
Washington, DC 20208

Dr. Vern W. Urry
Personnel R and D Center
U.S. Civil Service Commission
1900 E Street NW
Washington, DC 20415

Dr. Joseph L. Young, Director
Memory and Cognitive Processes
National Science Foundation
Washington, DC 20550

Non Government

Dr. Earl A. Alluisi
HQ, AFHRL (AFSC)
Brooks AFB, TX 78235

Dr. Erling B. Anderson
University of Copenhagen
Studiestraedt
Copenhagen
Denmark

1 Psychological Research Unit
Dept. of Defence (Army Office)
Campbell Park Offices
Canberra ACT 2600, Australia

Dr. Alan Baddeley
Medical Research Council
Applied Psychology Unit
15 Chaucer Road
Cambridge CB2 2EF
England

Dr. Isaac Bejar
Educational Testing Service
Princeton, NJ 08450

Dr. Warner Birice
Streitkaefteamt
Rosenberg 5300
Bonn, West Germany D-5300

Dr. R. Darrel Bock
Department of Education
University of Chicago
Chicago, IL 60637

Dr. Nicholas A. Bond
Dept. of Psychology
Sacramento State College
600 Jay Street
Sacramento, CA 95819

Dr. David G. Bowers
Institute for Social Research
University of Michigan
Ann Arbor, MI 48106

Dr. Robert Brennan
American College Testing Programs
P.O. Box 168
Iowa City, IA 52240

Dr. C. Victor Bunderson
Wicat Inc.
University Plaza, Suite 10
1160 So. State St.
Orem, UT 84057

Dr. John B. Carroll
Psychometric Lab
Univ. of No. Carolina
Davie Hall 013A
Chapel Hill, NC 27514

Charles Meyers Library
Livingston House
Livingston Road
Stratford
London E15 2LJ
England

Dr. Kenneth E. Clark
College of Arts and Sciences
University of Rochester
River Campus Station
Rochester, NY 14627

Dr. Norman Cliff
Dept. of Psychology
Univ. of So. California
University Park
Los Angeles, CA 90007

Dr. William Coffman
Iowa Testing Programs
University of Iowa
Iowa City, IA 52242

Dr. Allan M. Collins
Bolt Beranek and Newman, Inc.
50 Moulton Street
Cambridge, MA 02138

Dr. Meredith Crawford
Department of Engineering
Administration
George Washington University
Suite 805
2101 L Street N. W.
Washington, DC 20037

Dr. Hans Cronbag
Education Research Center
University of Leyden
Boerhaavelaan 2
Leyden
The Netherlands

Major I.N. Evonic
Canadian Forces Pers. Applied Research
1107 Avenue Road
Toronto, Ontario, Canada

Dr. Leonard Feldt
Lindquist Center for Measurement
University of Iowa
Iowa City, IA 52242

Dr. Richard L. Ferguson
The American College Testing Program
P.O. Box 168
Iowa City, IA 52240

Dr. Victor Fields
Dept. of Psychology
Montgomery College
Rockville, MD 20850

Dr. Gerhardt Fischer
Liebigasse 5
Vienna 1010
Austria

Dr. Donald Fitzgerald
University of New England
Armidale, New South Wales 2351
Australia

Dr. Edwin A. Fleishman
Advanced Research Resources Organ.
Suite 900
4330 East West Highway
Washington, DC 20014

Dr. John B. Frederiksen
Bolt Beranek and Newman, Inc.
50 Moulton Street
Cambridge, MA 02138

Dr. Robert Glaser
LRDC
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15213

Dr. Ross Greene
CTB/McGraw Hill
Del Monte Research Park
Monterey, CA 93940

Dr. Alan Gross
Center for Advanced Study in Education
City University of New York
New York, NY 10036

Dr. Ron Hambleton
School of Education
University of Massachusetts
Amherst, MA 01002

Dr. Chester Harris
School of Education
University of California
Santa Barbara, CA 93106

Dr. Lloyd Humphreys
Department of Psychology
University of Illinois
Champaign, IL 61820

Library
HumRRO/Western Division
27857 Berwick Drive
Carmel, CA 93921

Dr. Steven Hunka
Department of Education
University of Alberta
Edmonton, Alberta
Canada

Dr. Earl Hunt
Dept. of Psychology
University of Washington
Seattle, WA 98105

Dr. Huynh Huynh
Department of Education
University of South Carolina
Columbia, SC 29208

Dr. Carl J. Jensema
Gallaudet College
Kendall Green
Washington, DC 20002

Dr. Arnold F. Kanarick
Honeywell, Inc.
2600 Ridgeway Pkwy
Minneapolis, MN 55413

Dr. John A. Keats
University of Newcastle
Newcastle, New South Wales
Australia

Mr. Marlin Kroger
1117 Via Goleta
Palos Verdes Estates, CA 90274

LCOL. C.R.J. Lafleur
Personnel Applied Research
National Defence HQS
101 Colonel By Drive
Ottawa, Canada K1A OK2

Dr. Michael Levine
Department of Psychology
University of Illinois
Champaign, IL 61820

Dr. Robert Linn
College of Education
University of Illinois
Urbana, IL 61801

Dr. Frederick M. Lord
Educational Testing Service
Princeton, NJ 08540

Dr. Robert R. Mackie
Human Factors Research, Inc.
6780 Cortona Drive
Santa Barbara Research Pk.
Goleta, CA 93017

Dr. Gary Marco
Educational Testing Service
Princeton, NJ 08450

Dr. Scott Maxwell
Department of Psychology
University of Houston
Houston, TX 77025

Dr. Sam Mayo
Loyola University of Chicago
Chicago, IL 60601

Dr. Allen Munro
Univ. of So. California
Behavioral Technology Labs
3717 South Hope Street
Los Angeles, CA 90007

Dr. Melvin R. Novick
Iowa Testing programs
University of Iowa
Iowa City, IA 52242

Dr. Jesse Orlansky
Institute for Defense Analysis
400 Army Navy Drive
Arlington, VA 22202

Dr. James A. Paulson
Portland State University
P.O. Box 751
Portland, OR 97207

Mr. Luigi Petrullo
2431 N. Edgewood Street
Arlington, VA 22207

Dr. Steven M. Pine
4950 Douglas Avenue
Golden Valley, MN 55416

Dr. Diane M. Ramsey-Klee
R-K Research and System Design
3947 Ridgemont Drive
Malibu, CA 90265

Min. Ret. M. Rauch
P II 4
Bundesministerium Der Verteidigung
Postfach 161
53 Bonn 1, Germany

Dr. Peter B. Read
Social Science Research Council
605 Third Avenue
New York, NY 10016

Dr. Mark D. Reckase
Educational Psychology Dept.
University of Missouri-Columbia
14 Hill Hall
Columbia, MO 65201

Dr. Andrew M. Rose
American Institutes for Research
1055 Thomas Jefferson St. NW
Washington, DC 20007

Dr. Leonard L. Rosenbaum, Chairman
Department of Psychology
Montgomery College
Rockville, MD 20850

Dr. Ernst Z. Rothkopf
Bell Laboratories
600 Mountain Avenue
Murray Hill, NJ 07974

Dr. Donald Rubin
Educational Testing Services
Princeton, NJ 08450

Dr. Larry Rudner
Gallaudet College
Kendall Green
Washington, DC 20002

Dr. J. Ryan
Department of Education
University of South Carolina
Columbia, SC 29208

Prof. Fumiko Samejima
Dept. of Psychology
University of Tennessee
Knoxville, TN 37916

Dr. Robert J. Seidel
Instuctional Technology Group
HumRRO
300 N. Washington St.
Alexandria, VA 22314

Dr. Kazoa Shigemasu
University of Tohoku
Department of Educational Pschology
Kawauchi, Sendai 982
Japan

Dr. Edwin Shirkey
Department of Psychology
Florida Technological University
Orlando, FL 32816

Dr. Richard Snow
School of Education
Stanford University
Stanford, CA 94305

Dr. Robert Sternberg
Dept. of Psychology
Yale University
Box 11A, Yale Station
New Haven, CT 06520

Dr. Albert Stevens
Bolt Beranek and Newman, Inc.
50 Moulton Street
Cambridge, MA 02138

Dr. Patrick Suppes
Institute for Mathmatical Studies in the Social Services
Stanford University
Stanford, CA 94305

Dr. Hariharan Swaminathan
Laboratory of Psychometeric and Evaluation Research
School of Education
University of Massachusetts
Amherst, MA 01003

Dr. Brad Sympson
Elliott Hall
University of Minnesota
75 E. River Road
Minneapolis, MN 55455

Dr. Kikumi Tatsuoka
Computer-based Education Research Laboratory
252 Engineering Research Laboratory
University of Illinois
Urbana, IL 61801

Dr. David Thissen
Department of Psychology
University of Kansas
Lawrence, KS 66044

Dr. J. Uhlaner
Perceptronics, Inc.
6271 Variel Avenue
Woodland Hills, CA 91364

Dr. Howard Wainer
Bureau of Social Science Research
1990 M Street, N. W.
Washington, DC 20036

Dr. Thomas Wallsten
Psychometric Laboratory
Davie Hall 013A
University of North Carolina
Chapel Hill, NC 27514

Dr. David J. Weiss
N660 Elliott Hall
University of Minnesota
75 E. River Road
Minneapolis, MN 55455

Dr. Susan E. Whitely
Psychology Department
University of Kansas
Lawrence, Kansas 66044

Dr. Wolfgang Wildgrube
Streitkraefteamt
Rosenberg 5300
Bonn, West Germany D-5300

Dr. Robert Woud
School Examination Department
Universtiy of London
66-72 Gower Street
London WCIE 6EE
England

Dr. Karl Zinn
Center for Research on Learning
and Teaching
University of Michigan
Ann Arbor, MI 48104